REAL-TIME NODE TRACKING LONG RANGE WIDE AREA MESH NETWORK

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Abstract - Communication in remote areas is challenging. LoRa is a promising wireless technology for low-power communication in remote areas. LoRa can transmit data over greater distances using very little energy. This research has been motivated by the need for versatile, low-power consumption technology that enables GPS tracking. The proposed mesh network uses LoRa technology to build an architecture that can track and monitor the location of nodes across extensive regions. Within a range of more than 30 kilometres, it can identify the position of the connected device. By establishing a LoRa network, an individual with access to the LoRa Network can monitor the location and routes of end devices.

Keywords - LoRa, Gateway, GPS, Tracking.

I. INTRODUCTION

At present, outdoor localization is mainly done using Global Navigation Satellite System (GNSS) receiver. The GNSS receivers are also used in other applications like tracking pets, undomesticated(untamed)animals, and goods. In attendance, there are reasonably priced GPS receivers available in the market. Still, the primary issue here is the battery life; these batteries must be recharged within a certain number of days. The current utilization of a GPS receiver is about 30-50mA, which is significantly high energy. In LoRa, the endpoint Network chains two ways: bidirectional communication, multicast enabling software upgrades over the air, and other mass allocation messages. LoRa also addresses the need for protection by providing end-to-end encryption at all three levels: Network, device, and application.

LoRa spreads the interaction involving the end-devices and gateways across numerous frequency channels and data rates. Here the spread spectrum technology is used, and the spread spectrum uses data rates which are ranging from 0.3 kilobits per second (kbps) to 50 kilobits per second to prevent communications from meddlesome with one another and provides a set of "effective" channels that increases the capability of the gateways. LoRa network maintains the data rate and the Radio Frequency outputs for each and every end-device independently through a method of adaptive data rate (ADR) scheme. Additionally, it provides the need for security measures by providing end-to-end encryption at the three levels: network level, application level, and device level through the utilization of its only one kind of network key (EUI64), a specific application key (EUI64), and a device-specific-application key (EUI128).

LoRa network is a wireless communication skill which provides us with the accessibility of utilization of consumption of low-power, low-rate and long-range communication. The communication networks of LoRa are like that of Wi-Fi networks, where the network devices communicate through LoRa gateways.

Gateways typically scan the corresponding spectrum, except for LoRa data packets from workstation devices, and forward the data to connected application services in the network server, which can process the data packets. The network server also accumulates metering data, and users can look up metering data on the application server. Power management center's handle network and application servers.

LoRa employs the open industrial, scientific, and medical radio band (ISM band) and has a 22-kilometre communication range [1]. Spreading factor, coding rate, and bandwidth affects data rate and airtime [2]. This suggests LoRaWAN systems should be carefully planned and dimensioned to maximize scalability and efficiency. However, LoRa/ LoRaWAN's physical layer and link layer performance has been field-tested. Trials have been undertaken in indoor, urban/suburban, coastal, rural, and mountain settings. The total experiment shows that the communication range is 10-30 km in the countryside and 2-8 kilometers in the inner city. In addition, the influence of environmental elements including heat and vegetation has been studied [3], [4]. It has been shown that vegetation and higher temperature significantly reduce communication range.

Lora has been tested in various fields, including automobile-to-grid communications, physical condition monitoring, etc. In the current era, there is a

new method for selecting communication technologies known as low-power wide-area (LPWA) networks, which are expected to specifically address the needs of Long-range and Low-power Internet of things (IoT) applications. LPWAN utilizes the sub-GHz band and is intended to provide coverage of several kilometers in an open-air environment, as opposed to conventional 2.4-GHz standards, which suffer from poor saturation capability and heavy in-band interference.

The development of the LoRa Network is to provide communication and security in real-time at designated areas with the help of sensors connected to LoRa devices to track end nodes. LoRa based antennas can be mounted onto basic cost-effective microcontrollers or microprocessors, allowing for the reinforcement of the sensor and GPS.

If an active communication link is maintained, the resolution of trajectories could be largely improved to such details that analyzing and tracking relative locations between two nodes to observe behavior may be feasible with no eyes on the ground. Later in this paper section II describes about the working of LoRaWAN and its architecture, section III explains the proposed work, section IV discusses the possible applications, and in last section V concludes the work.

II. LORAWAN

LoRaWAN is an industrialized version of an unwrapped standard architecture that enables End-Devices (ED) to interact with a single gateway or many gateways. LoRa is a physical layer technology that enables low-power, long-range wireless communications at high data speeds. By modulating signals in the sub-GHz ISM bands, LoRa does not require a license since it operates in an unlicensed band and uses a commercialized semiconductor and spread spectrum technology. Peer-to-peer communication between nodes is made possible using LoRa technology.

A. Architecture

As shown in Fig. 1, the LoRaWAN Alliance employs a star network topology in which a gateway seamlessly relays messages between a Network Server (NS) and an End Device (ED). End devices use LoRa to communicate with Gateways (GW).
The IP network is the medium via which Gateway connects with the server. Multiple frequency channels are used to facilitate communication between devices and gateways, with information transfer rates set according to the distance between the two and the time between messages. Using an Adaptive Data Rate (ADR) strategy, the LoRaWAN network architecture can determine each device's data rate and channel.

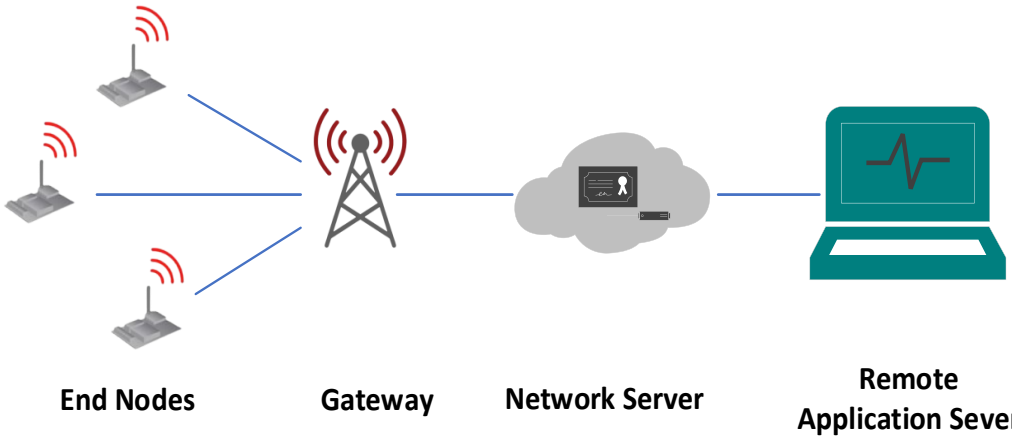


Fig. 1. LoRaWAN Architecture

B. LoRaWAN Communications

As illustrated in Fig. 2, the LoRaWAN Alliance stipulations define three types of End-Devices based on their communication. These three classes each have the distinct ability to cover a wide range of applications. Each class represents a trade-off between battery life and network downlink communication latency. End Devices can switch between classes based on their needs; however, class A must be implemented on all devices by default. In the next section proposed work is explained.

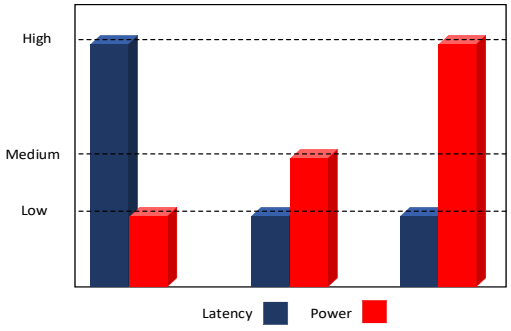


Fig. 2. Network Device Classes

III. PROPOSED WORK

The suggested model is intended to be used in the creation of a LoRa device for a real-time node tracking system utilizing a LoRa network in rural regions. A tracking system is used to keep tabs on a moving object while also providing a time-stamped, sequential position report for processing. It uses GPS or other short-term methods of sampling a device's location to create a unique identifier for each unit.

When a user with a LoRa-enabled device wants to keep records on an end node located on the other side of an equivalently wide area. The user can establish a two-way connection between the gateways and the cloud, where the transfer management centre would be housed in the form of a web-based interface.

Fig. 3. represents the network that highlights the system's technological components in the star network. The coverage area provided by a star-configured LoRa network would be in the range of up to 22km in Line of Sight (LoS) links and around 2km in an urban region with buildings [15]. Similarly, the realistic range of LoRa in the presence of trees would largely vary [16].

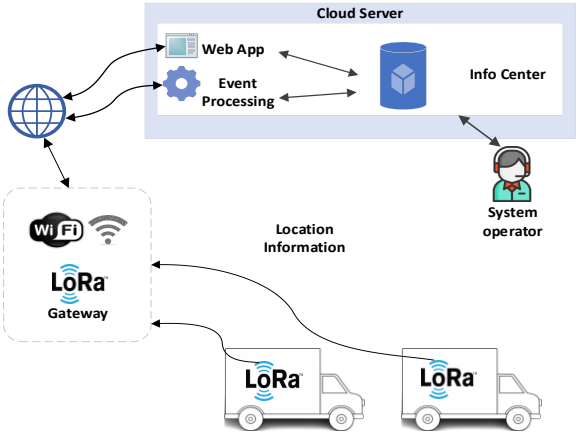


Fig. 3. Network Tracking Diagram

Using the LoRa network system would be impractical as the area to be covered increases. This brings the need for alternative solution to solve the problem. A network model is proposed in this regard.

A simple replacement would be to install gateway units; nevertheless, it is common for a gateway to be connected to the external network and to be available to users. Making this kind of access available at each and every gateway would be impractical. In response to this, it is possible that the user will only have direct access to a single (or a few) gateways, while the remaining gateways will connect with the user by way of the directly accessible gateway.

Fig. 4 shows the Model configuration, which involves adding LoRa gateway routers to expand the coverage area. The LoRa gateways are to be placed in the most advantageous geographical locations possible, with attention given to aspects like the terrain, movement patterns, and so on. At least one of the gateways is to be designated the "Root," and those same gateways will have active network connectivity; as a result, they will be immediately accessible by the user either through the internet or the cloud or through a local setup. In order to broaden the region that is covered by the network, the remaining gateways will serve as mesh repeaters. If the area's topography permits it, the gateways might be installed atop poles constructed to provide line-of-sight connections. In Fig. 4, the LoRa Node denoted by the letter 'C' is located a considerable distance from the region serviced by the gateway router, shown by the letter 'X,' which serves as the primary point of network communication.

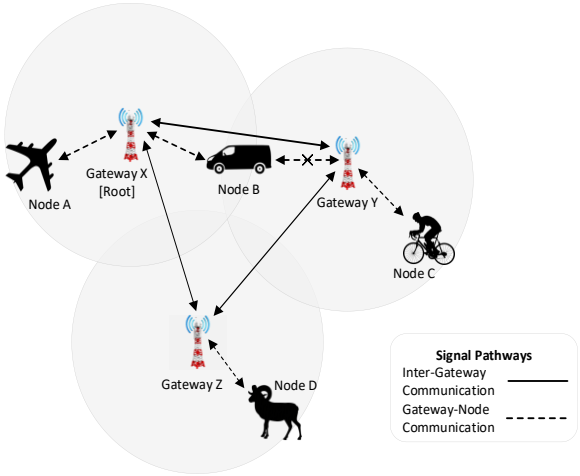


Fig. 4. Mesh Network with Multiple LoRa Gateways

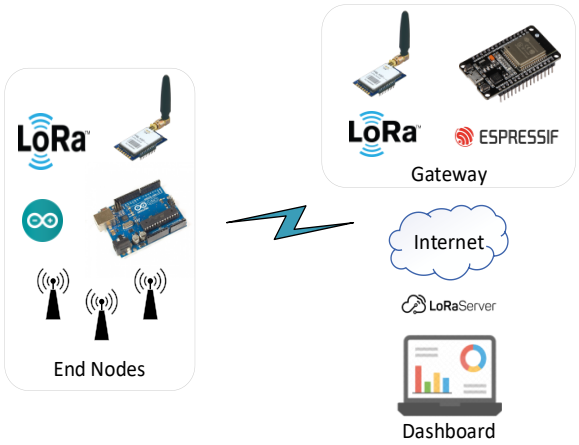


Fig. 5. LoRa Communication Components Overview

However, Node "C" is situated inside the region of coverage of gateway router "Y," which functions in the capacity of a repeater. This might be accomplished with specialized higher layers or done using LoRaWAN [17]. The data will first be collected from Node "C" by Gateway router "Y," which will then send it to the root gateway router "X," after which the data will be able to be uploaded to the server or the cloud. Routing information is periodically transmitted from the root gateway router to all the network gateways and nodes.

This ensures that both the nodes and the gateways know the path leading to the root node. Due to the fact that node 'B' is located at the point where gateway routers 'X' and 'Y' intersects, it is able to transmit to any of the gateway routers, but it will only send to the root gateway router. The representation in Fig. 5 tells us about the structural design of our LoRa-based GPS monitoring systems. The LoRa location monitoring system consists of four components: (1) LoRa end node, (2) LoRaWAN Gateway, (3) LoRa Server and (4) Dashboard. These are described below:

1) LoRa end node:
The monitoring module consists of an end node which utilizes the GPS sensors which are associated to a LoRa transceiver.
The LoRa End-nodes are used:

- To get the GPS information of the node.
- To-send: According to the LoRaWAN specification the obtained data is sent to the LoRaWAN Gateway.

2) LoRaWAN Gateway:
It takes
1. LoRa Concentrator board to make up the LoRaWAN gateway,
2. A computer system that acts as a host. LoRaWAN gateways perform the conversion from IP packets to LoRa Radio Frequency packets.
The concentrator sends the RF packets to the Host. Finally, a packet forwarder is set up to take the RF packets received by the concentrator and convert them to User Datagram Protocol (UDP) packets, which are then transmitted over the Internet to a correctly set up LoRaWAN server. The LoRa concentrator has built-in buffers to keep data from being lost in the case of a connection failure.

3) LoRaWAN Server:
Whenever a data packet is sent from a LoRa end node through a gateway, it will arrive at the LoRaWAN server. The server verifies their authenticity, decrypts the data, and saves it in a NoSQL database for further use and analysis. All the data is graphically shown in real time using a dashboard.

4) Dashboard:
The Dashboard is a Web-based interface accessible from any computer or mobile device, enabling remote user monitoring of the end nodes. Possible applications of the system are discussed in the next section.

IV. APPLICATIONS

The designed system can be used for theft protection of electrical transformers (a major problem electrical companies facing) and vending machines, vehicle tracking, garbage management, parking and vehicle management, shipment tracking etc.

LoRa provide several benefits to use in such applications like; it uses low powered sensors with a coverage range of several kilometres, is resilient to jamming and hacking, has battery life that lasts for more than 2-5 years, has end-to-end security encryption and provides bi-directional communication. This makes LoRa the best solution for such applications.

V. CONCLUSION

A potential wireless technology called LoRa (Long range) is employed for low-power communication in remote places like forests and deserts. Because of this use, there is a significant need for a system that is adaptable and energy efficient and makes use of GPS for geolocation. By establishing a LoRa network, an individual with access to the LoRa Network can monitor the location and routes of end devices.

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